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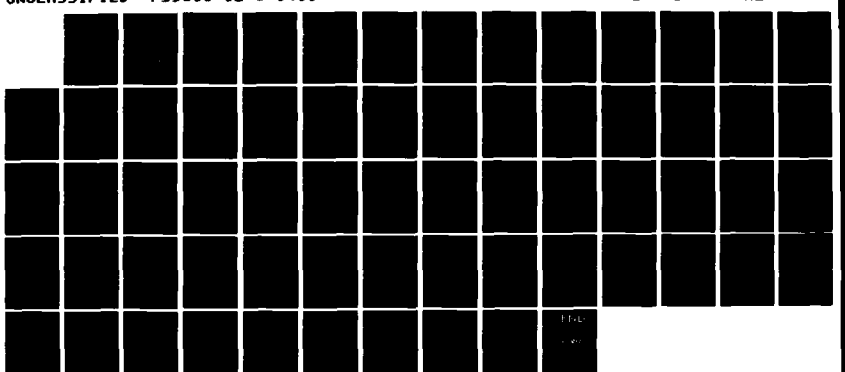

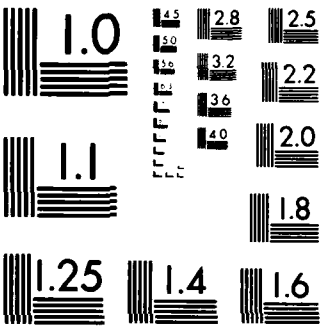

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Applied Research in Statistics - Mathematics - Operations Research

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This study is the first of a set of reports documenting the findings of a study conducted by Desmatics, Inc. for the Office of VAMOSC, Air Force Logistics Command. This study constitutes an assessment of the cost allocation algorithms employed within the Communciations-Electronics (C-E) subsystem of VAMOSC, the Air Force Visibility and Management of Operating and Support Cost system.

This volume examines the criteria used to select and categorize records from the E300Z Advanced Personnel Data System (MPC) for C-E unit mission

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20. personnel. It also evaluates the methods used to allocate their pay and allowances costs to the items of communications-electronics equipment of their organizations. Alternative procedures are recommended to correct certain omissions and misallocations identified in the study.

EXECUTIVE SUMMARY

This report by Desmatics, Inc. is the first in a series of volumes which review procedures used by the Ground Communications-Electronics (C-E) subsystem of the Air Force Visibility and Management of Operating and Support Costs (VAMOSC) system to allocate operating and support costs to Air Force ground communications-electronics equipment. It presents an evaluation of the criteria C-E uses to select and categorize unit mission personnel records, and discusses the results of an examination of algorithms and data used by C-E to allocate unit mission personnel costs to the Type Model Series (TMS) level.

Desmatics considers the current C-E personnel selection logic, which employs numerous Functional Account Code/Air Force Specialty Code (FAC/AFSC) combinations, to be suboptimal. In Desmatics' opinion certain personnel are improperly categorized, and several relevant personnel types and their associated costs are not considered for allocation. Desmatics recommends that the Office of VAMOSC review the present selection process. Also, Desmatics puts forth an alternative personnel selection procedure which provides for the inclusion of additional personnel which are considered relevant. Desmatics further recommends that C-E portray the personnel strengths associated with a TMS. Personnel can be allocated to the TMS by the same means as the corresponding costs.

The Operations Personnel Cost algorithm allocates costs with what is called an operator factor. An assumption implicit in the use of the operator factor is that the distribution of pay grades is the same in each of the operations career fields. However, Desmatics has shown this not to be the case. Thus, the operator factor results in an in-

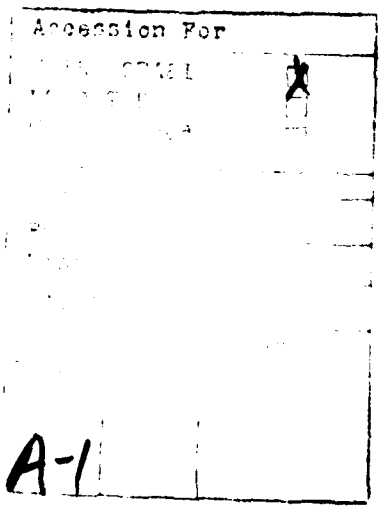
correct allocation of these costs. Desmatics recommends that the Office of VAMOSC collect additional operator data from the C-E units in order to develop modified operator factors.

The Base Maintenance Personnel Cost algorithm is influenced by maintenance man-hour reporting exemptions, which result in a misstatement of the maintenance costs. Desmatics recommends that the Office of VAMOSC encourage the elimination of these exemptions. In the meantime, the Office of VAMOSC should indicate those items affected by reporting exemptions on the Operating and Support (O&S) Cost reports. Desmatics also recommends two alternatives to the present base labor allocation factor. One alternative, the addition of an efficiency factor to account for the true nature of the maintenance workload, can and should be used in the presence of reporting exemptions. The other alternative, involving a change to a ratio of reported man-hours must wait to be implemented until reporting exemptions are eliminated. Finally, the Office of VAMOSC should investigate the feasibility of capturing contracted operations and below depot maintenance costs and allocating them to the TMS level.

In Desmatics' opinion, the unit TMS factor is inappropriate for the allocation of both administrative and supply support personnel costs. A more germane allocation for both types of costs would be to use the personnel strength ratios suggested by Desmatics. Desmatics considers a plan by the Office of VAMOSC to reclassify those personnel currently considered supply support as administrative personnel as reasonable and appropriate.

In summary, Desmatics makes several specific recommendations for

changes in C-E processing, and raises other points for consideration by the Office of VAMOSC regarding possible further enhancements to the Unit Mission Personnel algorithms. Action on these recommendations should improve the C-E system, thus increasing the utility of C-E reports.



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I. INTRODUCTION

Desmatics, Inc., under Contract No. F33600-82-C-0466, is conducting an evaluation of the cost allocation algorithms employed in the Ground Communications-Electronics (C-E) Subsystem (D160A) of VAMOSC, the Air Force Visibility and Management of Operating and Support Costs System. This report is the first in a set of volumes which discuss the scope and findings of the Desmatics evaluation efforts.

The purpose of this volume is to evaluate the C-E procedures for allocating the following Unit Mission Personnel costs to C-E end items at the Type Model Series (TMS) level: Operations, Base Maintenance, Administrative, and Supply Support. Throughout this report the terms "TMS" and "end item" are used synonymously. This report consists primarily of a qualitative examination which evaluates the face validity of the C-E system logic. It evaluates the reasonableness of the procedures used for selecting, classifying, and allocating the above-mentioned costs to TMSs, assessing whether they may be expected to provide equitable results. Quantitative evaluations are included where appropriate. Desmatics has made a number of specific recommendations which are enumerated in Section VIII of this report. The corresponding responses and comments of the Office of VAMOSC accompany each recommendation.

The Statement of Work under which this Desmatics study was initiated calls for the evaluation of the C-E system algorithms as set forth in the draft of the C-E User's Manual dated 1 July 1981. The current edition of this manual, AFR 400-31, Volume III, dated 12 August 1982, was used for the evaluations in this volume. The C-E system has evolved almost con-

tinually since its inception, reflecting improvements that were made in virtually every aspect of the system prior to the first production runs in September 1982. Additional modifications and enhancements have been made for the second run and more are planned for the immediate future.

Desmatics recognizes that to restrict its evaluation to the July 1981 baseline would significantly limit the usefulness of its findings. Accordingly, Desmatics has kept pace with the evolution of the C-E system and has attempted to reflect the significant system changes, specifically in those instances where a given cost was computed by different algorithms in FY81 and FY82. As a result, the documentation of Desmatics' findings is more complex than might otherwise be the case. The reader may expect frequent encounters with the phrases "for FY81," and "for FY82."

It should also be pointed out that at the time of submission of this report, Desmatics had access to only a limited amount of data from the D160A initial production run (FY81); none of the FY82 data was yet available. Thus, the evaluations presented by Desmatics in this volume are based primarily on the review of D160A system and interface system documentation, without the benefit of many significant items of actual D160A output data. Because of this situation, the investigations of some areas, which could have been augmented by an in-depth data examination, were necessarily constrained.

Desmatics has endeavored to have this volume reflect the current status of the Unit Mission Personnel cost allocation algorithms within the C-E system. The authors feel that this has been accomplished. However, the reader must realize that should future C-E system changes impact on the algorithms discussed, portions of this report may become outdated.

II. BACKGROUND

The USAF VAMOSC program has evolved in response to memoranda to the secretaries of the military departments from the Deputy Secretary of Defense in 1975 and 1976 [1,2]. These documents specifically tasked the military departments to standardize O&S cost terminology across the services, and develop systems to provide visibility and management of operating and support costs.

Currently, the AF VAMOSC program is a management information system composed of three major modules:

(1) WSSC (Weapon System Support Cost) [17] which collects, computes, and displays costs for aircraft at the Mission Design Series (MDS) level,

(2) C-E (Ground Communications-Electronics) [18] which similarly provides costs for ground C-E equipment at the Type Model Series (TMS) level,

and (3) CSCS (Component Support Cost System) [19] which provides visibility of maintenance and support costs for aircraft (and associated engines) subsystems and components.

The data system designators (DSDs) for the three systems are currently D160., D160A and D160B respectively. Another module called VAMOH (VAMOSC Overhead) is a subsystem which preprocesses selected data for the WSSC and C-E modules. The VAMOH subsystem is to be established with a separate DSD.

A. HISTORY OF THE C-E SYSTEM

The C-E data system originated with a model known as the Communications-Electronics Logistics Support Cost (LSC) Management Program developed contractually by AF/LEYE beginning in 1976 [20,21]. The major elements

of the logistics support costs in this system were: (1) base-level maintenance labor, (2) base-level maintenance materiel, (3) depot maintenance labor and materiel (including contractor and mobile depot maintenance), (4) replacement end items and recoverable assemblies, and (5) two-way transportation and packaging costs for recoverables sent to the depot for repair. The objectives of the system were to obtain visibility of the above costs for ground C-E equipment, and to provide improved data for the following activities: (1) trade-off analyses involving new acquisitions, replacement equipment, and modifications, (2) planning, and (3) budgeting. The LSC program was constrained to use existing management information systems as input, without configuration management or Memorandums of Agreement (MOAs) with feeder data systems. Therefore the LSC was not developed as a data system in accordance with AFR 300-12 and AFR 300-15.

The current C-E data system is designed to collect, compute and portray the five support costs previously supplied by LSC plus fourteen additional operating and support costs [18]. These nineteen cost categories are listed in Figure 1. C-E equipment is of six basic types: ground radio, ground radar, meteorological, communications systems, special computers and data processors, and ground intrusion detection systems. Each TMS is identified in the C-E system interfaces by a three character Standard Reporting Designator (SRD) and a thirteen digit National Stock Number (NSN). The system interfaces which provide inputs to C-E are listed in Figure 2. C-E currently provides costing for approximately fifteen hundred end items [10].

The Cost Analysis Improvement Group (CAIG) within the Office of the Secretary of Defense (OSD) has established a set of guidelines

Unit Mission Personnel
- Operations Personnel
- Base Maintenance Personnel
- Administrative Personnel
- Supply Support Personnel

Unit Level Consumption
- Fuel
- Maintenance Materiel
- Utilities

Depot Maintenance

Replacement Investment

Installation Support
- Base Operating Support
- Real Property Maintenance
- Communications

Indirect Personnel Costs
- Temporary Duty (TDY)
- Permanent Change of Station
- Unit Mission Personnel Health Care

Depot Non-Maintenance
- General Depot Support
- Engineering Support
- Transportation and Packaging

Advanced Training

Figure 1: C-E Operating and Support Costs

Data System Designator	Name
C003K	AFCC Engineering/Installation Management System
D039	Equipment Item Requirements Computation System
D041	Recoverable Consumption Item Requirements System
D056A	Edit/Error Analysis Subsystem of Product Performance System
D160.	Weapon System Support Cost System
D160B	Component Support Cost System
F006	Command Civil Engineering and Military Family Housing Cost System
H036B	Depot Maintenance Industrial Fund Cost Accounting
0013	Packaging and Transportation Data Maintenance System

Figure 2: C-E System Interfaces

primarily for preparing O&S cost analysis for aircraft acquisition programs submitted to the Defense Systems Acquisition Review Council (DSARC) for review [5]. These guidelines additionally define the relevant cost categories for consideration in life cycle cost estimating. Although these guidelines do not specifically apply to C-E, they can be used as a general framework for C-E reporting, and were used in the original C-E design wherever possible.

B. C-E SYSTEM OUTPUTS AND ALLOCATION PROCEDURES

The C-E system produces two main types of products: system products and demand products. They display costs in "then year" dollars (e.g., the costs displayed in FY82 reports are in 1982 dollars). The main system product is the annual C-E O&S Cost Report (RCS:HAF-LEY(A) 8117). In addition there are seven logistic support cost reports which show, in detail, the data used in the computation of the five direct logistic support costs in the O&S cost reports: (1) below depot maintenance labor, (2) below depot maintenance materiel, (3) depot maintenance labor and materiel, (4) mobile depot maintenance and materiel, and (5) transportation and packaging costs of recoverable assemblies. There are also a number of ranking reports which allow various cost comparisons between TMSs. One of these, for example, provides a ranking of current year total O&S costs for all end items.

The two kinds of demand products are called C-E Routine Data Base Extractions and C-E Complex Data Base Extractions. The former contain selected information which can be directly extracted from the data base files. The latter contain other kinds of user-specified data which

can be obtained by manipulation of the historical data through special programming.

Much of the cost data from existing data sources cannot be traced directly to the TMS level; therefore, these costs must be allocated on some reasonable basis. The procedures used in collecting and allocating costs to TMSs are described in the following source documents:

(1) AFR 400-31, Volume III, C-E User's Manual [18],

(2) C-E System Specification D160A [7],

(3) Subsystem Specification of the Preprocessor (VAMOH) [11],

(4) C-E Training Conference Handouts, 1982 [9],

(5) C-E User/Final Operational Evaluation (FOE) Conference Handouts, 1983 [10],

and (6) relevant Data Automation Requirements.

A number of different methods are used to allocate costs. They include the use of personnel strength ratios, relative inventory values of C-E end items, and factors computed by the Office of VAMOSC or supplied by other Air Force activities.

The cost allocation procedures evaluated in this volume involve Communications-Electronics Unit Mission Personnel costs: Operations, Base Maintenance, Administrative, and Supply Support. The evaluation comprises six separate sections. The first discusses the selection and classification of C-E Unit Mission personnel. The following four sections discuss each personnel cost category separately. Each of these five sections includes a process description, an evaluation of the face validity of the process or algorithm and a review of the appropriateness of the input sources. The discussions also include the results of an examination of input data.

The last section summarizes e conclusions and recommendations made by Desmatics based on its study of the algorithms for allocation of C-E Unit Mission Personnel costs. Replies from the Office of VAMOSC are also included.

III. C-E PERSONNEL SELECTION AND CLASSIFICATION

As mentioned previously C-E Unit Mission Personnel are currently grouped into four major categories: Operations, Base Maintenance, Administrative, and Supply Support. The first step in the development of costs for these personnel involves obtaining counts for each category in each C-E unit or organization. This section discusses the processes used in the C-E system in this initial step of each of the four algorithms for allocation of Unit Mission Personnel costs to end items.

A. PROCESS DESCRIPTION

To obtain counts for each category of personnel at each C-E organization, the C-E system selects records from the Military Personnel Center (MPC) Extract File. This file contains military and civilian personnel records selected for C-E from E300Z, Advanced Personnel Data System, by the VAMOH preprocessor subsystem. Each record contains the following information:

1. Geographical location (GELOC)
2. Command (CMD)
3. Program Element Code (PEC)
4. Personnel Accounting Symbol (PAS)
5. Organization Code
6. Functional Account Code (FAC)
7. Air Force Specialty Code (AFSC)
8. Flying Status
9. Grade
10. Number of Personnel
11. Permanent Change of Station (PCS) costs.

For FY81 the Extract File contained all personnel records with FACs of 38XX and 26XX; for FY82 selected FACs of 35XX were also included.

Each C-E unit or organization, as currently defined by the Office of VAMOSC, is uniquely identified both by its PAS and its organization code. This latter code is used for assignment of equipment inventories in the D039 data system. The FAC/AFSC combinations selected for each of the four categories of C-E Unit Mission Personnel for FY81 and FY82 are given in the C-E User's Manual [18] and the revised C-E System Specification [8], respectively. These combinations, for both FY81 and FY82, are summarized in Figures 3 and 4. Selection is accomplished in a stepwise process, not reflected in this summary, so that each record is counted only once. Records with FAC/AFSC combinations other than those specified are bypassed. The results of the changes in the C-E personnel selection processes between FY81 and FY82 are summarized below:

1. FACs 3820, 3821, 3830, 3840, 3850, 3860, 3870, 3890 through 3894, and selected FACs in the 35XX (Intelligence) series were added to the Operations category.

2. FACs 3841 through 3844 were eliminated from the Operations category, except for those with AFSC = 307XX.

3. FACs specified for inclusion in Operations when combined with an AFSC of 3XXXX (except for FAC/AFSC of 38XX/307XX) were eliminated.

4. All FACs in the 26XX series (other than 2600, 2610, and 2620) were included in Base Maintenance.

5. FAC/AFSC combinations involving AFSCs 301X0, 3XXX9, 362X0, 307XX, and 30XX were excluded from Base Maintenance.

6. FAC/AFSC combinations of 26XX/301X0, 362X0, 3XXX9, or 7XXXX, and 38XX/302X were added to Administration.

7. FAC/AFSC combinations of 38XX/7XXXX other than 38XX/702XX, 2600/64XX, 2600/645XX, 2610/64XX, 2610/645XX and 2620/64XX were excluded from Administration.

8. All FACs 26XX with AFSCs of 645XX or 64XX were included in Supply Support.

	FY81		FY82	
Personnel Category	FAC	AFSC	FAC	AFSC
Operations	3803 3810-3819 3822 3831-3835 3841-3845 3851-3854 3861-3863 3871-3873		3803 3810-3819 3820-3822 3830-3835 3840 3845 3850-3854 3860-3863 3870-3873 3890-3894 3511-3512 3515-3516 3518 3521 3523-3525 3562	A11 except 3XXXX
			38XX	307XX
Base Maintenance	2630 2640-2644 2650-2659 265A 2660 2670 2672 2680 2690 2692-2693 2699	3XXXX	26XX except 2600 2610 2620	3XXXX except 301X0 3XXX9 36200 307XX 30XX

Figure 3: C-E Operations and Base Maintenance Personnel Selection

	FY81		FY82	
Personnel Category	FAC	AFSC	FAC	AFSC
Administrative	2600 2610		2600 2610	All except 64XX 645XX
	2620	All except 645XX	2620	All except 64XX 645XX
	26XX	702XX	26XX	7XXXX 301X0 36200 3XXX9
	38XX	702XX	38XX	702XX 302XX
	3800-3802 3820 3830 3840 3850 3860 3870			
Supply Support	2620	645XX	26XX	645XX 64XX

Figure 4: C-E Administrative and Supply Support Personnel Selection

B. EVALUATION

This section presents Desmatics' assessment of the methods used to select unit level personnel from the files of the E300Z(MPC) system and classify them into the four unit personnel categories. Alternatives are suggested which will overcome certain limitations in the present logic. In conducting this evaluation, Desmatics examined: (1) relevant FAC descriptions from AFR 300-4 [15]; (2) relevant AFSC descriptions from AFR 36-1 and AFR 39-1 [8,9]; and (3) samples of MPC data extracted from the FY82 Consolidated Quarterly Military Personnel file from VAMOH.

In general, two types of problems were encountered. First, the system does not currently select personnel in C-E organizations unless they have FACs of 26XX, 35XX or 38XX, with the result that several types of unit personnel are completely excluded, principally those unit administrative and support personnel in non-C-E FACs. The system also excludes some personnel of C-E organizations even within FACs 26XX, 35XX and 38XX. Second, the system misclassifies some unit personnel. These problems are discussed in some detail in this section, and changes designed to overcome these difficulties are proposed in the following section.

If all relevant FAC/AFSC combinations are not specified in the selection of records from E300Z, the associated costs are lost for allocation purposes. In the data examined there are numerous examples of records which are bypassed despite the fact that the descriptions of the duties and responsibilities for the FAC/AFSC

combinations [12,13,15] indicate that they should be selected. For example, records involving FACs of 3800 or 3801 with AFSCs other than 702XX or 302X should be selected for adminstration. Other combinations involving FACs of 3841 through 3844 should be selected for operations. These latter records are currently bypassed as a result of one of the selection changes made for FY82. Another group of costs is lost because operations personnel in MAC meteorological units have assigned FACs in the 34XX series; these FACs are not selected by VAMOH for the C-E MPC extract. However, meteorological equipment is included in the C-E data base, and maintenance personnel for this equipment (FAC/AFSC combinations of 2680/302XX) are selected and costed.

Costs are lost as well if the FAC/AFSC combinations assigned are themselves conflicting. Operations-related FACs are sometimes combined with maintenance-related AFSCs and vice versa. The data examined contained a large number of records with operations-related FACs of 38XX combined with maintenance-related AFSCs causing these records to be bypassed when they should be selected for costing. For example, there were thirty individuals at Tinker AFB in FY81 assigned a conflicting combination of 3820/30474. These conflicts need to be resolved on a case by case basis.

Misclassification of unit personnel results in an overstatement of the associated costs for the assigned category and understatement for the proper category. This problem occurs with records having FACs of 38X0. From a description of the duties and responsibilities associated with these FACs, it appears that all records containing them, not just those with AFSCs of 702XX or 302X, should be assigned to administration. Records with these FACs and AFSCs other than 702XX or 302X

are currently assigned to operations.

Other personnel costs which Desmatics believes should be considered for direct allocation to end items are those related to vehicle operations and maintenance (AFSCs 603X0 and 472XX), generator maintenance (AFSCs 423XX and 542XX), and maintenance of air conditioning and heating systems (AFSCs 545X0 and 545X2). Records with these AFSCs were reviewed by Desmatics. With the exception of those records which would be selected for installation support costs (PECs XXX95 and XXX96), C-E will not include the associated costs anywhere for allocation to end items.

C. ALTERNATIVE PERSONNEL SELECTION PROCESS

This section outlines a method for selecting unit level personnel which is proposed as an alternative to the present C-E methodology. It is based on the assumption that while most C-E end items are owned and operated by organizations having a C-E mission, there are a considerable number of C-E end items which are owned and operated by organizations which are not C-E mission oriented. Desmatics currently does not have at hand the data to support this assumption. A way to test this would be to identify within the D039 file all organizations having C-E end items and then tabulate the personnel of these organizations by FAC and AFSC. Lacking any asset-by-organization data, Desmatics has based the following assessment solely on an examination of MPC data.

The present concept of the D160A system is based on the selection of unit personnel from three series of FACs (26XX, 35XX, and 38XX) which

are oriented toward C-E and intelligence operations and maintenance. These FACs contain the majority of C-E unit personnel of concern to the D160A system, but there are other personnel associated with C-E organizations whom Desmatics believes should also be treated as part of the cost of unit operations and maintenance of C-E end items. In fact, Desmatics contends that all relevant personnel on the roster of C-E organizations should be costed against its end items. However, it is also necessary to define carefully the concept of a C-E organization.

A large share of the C-E end items of concern to the D160A system are owned and operated by communications organizations within the AF Communications Command (AFCC). These units and similar units within other commands (such as aircraft control and warning units), have missions which relate primarily to C-E end items. They may be referred to as C-E mission organizations. All relevant personnel within such units should be costed against their C-E end items. The majority of the personnel in such organizations are reported in FACs 26XX or 38XX. However, some 35XX intelligence series personnel are often found in AFCC organizations and legitimately should be costed against the units' end items. In addition, there are administrative and support personnel found in other FACs within such organizations. Desmatics has examined a sample of the FY82 data for typical AFCC organizations and on the basis of their PECs, FACs and AFSCs can see no reason why these personnel should not be included as unit mission personnel.

On the other hand, there are certain types of organizations which own and operate C-E end items, but whose primary mission is not C-E oriented. These include a variety of Air Force elements (Defense Nuclear Agency, NATO, Joint Chiefs, and various intelligence and operations

units) which use C-E end items incidental to their primary missions. Desmatics contends that these end items should be represented in the D160A data base and certain of the personnel within such organizations should be costed against these end items; but unlike C-E organizations, it would not be appropriate to cost all unit personnel against these equipments.

Three problems are associated with the concept of non-C-E organizations, the first of which is to define them. The second is to establish a method for identifying the personnel who should be costed. The last problem is to decide whether or not to merge the data for end items in these organizations with that from C-E mission organizations.

Desmatics suggests that C-E mission organizations can be identified either by using an organization table prepared by the Office of VAMOSC, or by using a criterion based on the percentage of C-E personnel (identified by FAC, AFSC, or both) within the organization. For instance, any organization having, say, 80% of its personnel in FACs 26XX and 38XX or in C-E operations or maintenance AFSCs should be considered a C-E mission organization and all its personnel should then be costed against its C-E end items. Organizations having a smaller percentage (or none) should be considered to be incidental user organizations and only certain selected personnel should be costed.

Non-C-E mission units generally have no FAC 26XX or 38XX personnel, yet they may have C-E unit mission personnel (particularly operators) in other FACs, as indicated by AFSC. Desmatics therefore proposes the development of a list of AFSCs or FAC/AFSC combinations associated with C-E equipment, to be used in identifying personnel to be costed. While

the majority of such personnel are probably in FACs 26XX and 38XX, there are other FACs, such as 35XX for intelligence and 34XX for weather, where C-E AFSCs occur.

The personnel costs for C-E end items in non-C-E mission organizations will contain only costs for any operators and C-E maintenance personnel who can be identified by AFSC under the method outlined above. The rationale to include some fraction of the remaining unit personnel as administration in support of the C-E end items has not been developed and is not recommended at this time. As a consequence, the unit personnel costs for equipments owned by non-C-E organizations would not be compatible with those in C-E mission units. Desmatics recommends providing separate cost visibility for the items in these two ownership situations.

D. PORTRAYAL OF PERSONNEL STRENGTHS

The C-E system could provide additional useful information by portraying the personnel strengths associated with an end item. The Cost Analysis Improvement Group (CAIG) guidelines [1], although intended primarily for aircraft, can be applied analogously to the C-E system with respect to the portrayal of personnel strengths. In the area of unit mission personnel CAIG states, "...both cost and non-cost (number of people) estimates should be presented on these elements." A presentation of personnel strengths in a work-load distribution, as is done in the WSSC system, should increase the utility of the C-E O&S Cost Report. These personnel strengths can be allocated to each TMS using the same factors as are used to allocate costs to end items. For example, the

number of operators at an organization is determined from the MPC records that are selected by C-E to develop operations personnel cost. This operator count for an organization may be multiplied by the operator factor (currently used to allocate operations personnel costs) of each TMS at that organization to allocate personnel strengths to the end time in addition to cost. This strength figure can then be displayed on the O&S cost report. A similar process may be carried out for each of the remaining personnel categories (base maintenance, administrative, and supply support) using the allocation factor associated with each algorithm.

IV. OPERATIONS PERSONNEL COST

Operations personnel cost is the pay and allowances for personnel required to operate C-E end items. However, some of the end items included in the C-E VAMOSC system require no operators. The specific items requiring operators are identified in the Unit TMS Factor Table by a nonzero operator factor field. Operations personnel cost is allocated to these items only.

A. PROCESS DESCRIPTION

The following cost allocation was used in both FY81 and FY82 C-E processing. However, as mentioned in Section III, the criteria used to select operations personnel from E300Z records were different in each year. These records contain PAS, FAC, AFSC, grade, and the number of personnel.

The costs are computed by multiplying the number of operations personnel in each PAS/FAC/Grade combination by the average pay rate of that grade as given by pay tables from AFR 173-13 [14]. These costs are summed for all operations FACs within a PAS, thus giving the total operations personnel cost for an organization.

The organization's operations personnel cost is then allocated to the end items at that organization which require operators using a ratio called the operator factor. The operator factor [18] (one for each TMS at an organization) is defined as:

$$Op = \frac{t}{T}$$

where t = attended time of operating a particular C-E TMS at an organization during a 24-hour period,

and T = total attended time for operating all TMSs at that organization during a 24-hour period.

The operator factors are computed by the Office of VAMOSC based on operating information provided by each C-E organization on the VAMOSC C-E Unit Level Report (RCS: HAF-LEY(A)8119). The operator factor for a particular TMS at an organization is multiplied by the organization's total operations personnel costs, giving the operations personnel cost for that TMS. This organization level cost is then accumulated to the worldwide level for each TMS.

B. EVALUATION

Using actual assigned personnel strengths and average pay rates should provide a reasonably accurate estimate of the total operations personnel costs at a C-E organization. However, with respect to operations personnel cost, C-E is working under the constraint that no system is currently available to collect these costs directly at the end item level. In addition, C-E presently does not have data as to which operations personnel at an organization operate which equipments. Lacking this information, the C-E system pools all of the operations personnel costs for an organization and allocates it to all end items requiring an operator by way of the operator factor.

By allocating this pool of costs across the set of items requiring operators, it is implicitly assumed that the operators of a given end item are distributed by pay grade in the same proportion as the operators

of all other end items. If this assumption does not hold, this algorithm will allocate costs in a suboptimal manner. Desmatics examined FY82 E300Z (MPC) data to assess the validity of this assumption. What follows is a description of this analysis.

1. Analysis of Operations Personnel Data

The FY82 operations personnel selection process (summarized in Figure 1) was run against the FY82 C-E MPC Extract Personnel file. The resulting file was separated into enlisted, officer, and other personnel. The analysis concentrated on the enlisted personnel, as they comprise over 80% of the operations personnel.

The enlisted personnel data was grouped according to pay grade and the first three digits of duty AFSC. This was done to show how personnel in various types of C-E operations career fields are distributed by pay grade. A statistical analysis utilizing a chi-square test was then performed on the data. The chi-square procedure is designed to test the independence of two or more factors. In this case, the hypothesis to be tested is that the pay grade distribution is independent of AFSC or, equivalently, that the pay grade distribution is the same for each AFSC. The graphical device used to convey the relationship between the two factors is called a contingency table and is shown in Figure 5. The table displays the expected and observed frequency for each pay grade/AFSC combination or cell. The observed frequency is simply the number of people who actually have that particular pay grade/AFSC designation. The expected frequency is the number of persons to be found in the cell, on the average,

PAY GRADE

AFSC GROUP / FREQUENCY EXPECTED / CELL CHI2	EM01/EM02	EM03	EM04	EM05	EM06	EM07	EM08/EM09	TOTAL
202XX	20	247	211	122	43	18	7	668
	34.0	164.2	188.6	157.9	68.3	40.8	14.1	
	5.8	41.7	2.7	8.2	9.4	12.8	3.5	
205XX	8	59	35	29	16	18	5	170
	8.7	41.8	48.0	40.2	17.4	10.4	3.6	
	0.1	7.1	3.5	3.1	0.1	5.6	0.6	
207XX	53	701	398	282	122	49	2	1607
	81.9	395.1	453.7	379.9	164.4	98.3	33.8	
	10.2	236.9	6.8	25.2	10.9	24.7	29.9	
208XX	1	281	677	285	90	42	10	1386
	70.6	340.8	391.3	327.6	141.8	84.7	29.2	
	68.6	10.5	208.6	5.6	18.[illegible]	21.6	12.6	
272XX	215	924	1188	1466	610	492	192	5087
	259.2	1250.7	1436.3	1202.5	520.3	311.0	107.0	
	7.5	85.3	42.9	57.7	15.5	105.3	67.5	
276XX	130	377	491	471	234	141	39	1883
	96.0	462.9	531.6	445.1	192.6	115.1	39.6	
	12.1	16.0	3.1	1.5	8.9	5.8	0.0	
291XX	367	1207	1573	1025	429	194	83	4878
	248.6	1199.3	1377.3	1153.1	498.9	298.2	102.6	
	56.4	0.0	27.8	14.2	9.8	36.4	3.7	
293XX	107	408	313	272	115	63	9	1287
	65.6	316.4	363.4	304.2	131.6	78.7	27.1	
	26.2	26.5	7.0	3.4	2.1	3.1	12.1	
295XX	0	11	129	204	120	47	10	521
	26.5	128.1	147.1	123.2	53.3	31.9	11.0	
	26.5	107.0	2.2	53.1	83.5	7.2	0.1	
307XX	82	500	405	334	161	95	37	1614
	82.2	396.8	455.7	381.5	165.1	98.7	33.9	
	0.0	26.8	5.6	5.9	0.1	0.1	0.3	
311XX	3	42	43	84	39	24	13	248
	12.6	61.0	70.0	58.6	25.4	15.2	5.2	
	7.3	5.9	10.4	11.0	7.3	5.2	11.6	
TOTAL	986	4757	5463	4574	1979	1183	407	19349

CHI SQUARE 1830.328 DF = 60 PROB = 0.0001

Figure 5: Contingency Table of FY82 Data

if the hypothesis is true (i.e., if pay grade and AFSC are really independent). The expected frequency for each cell is calculated using some basic probability theory. If events A and B are independent, the probability of A and B occurring at the same time is the product of their respective probabilities, P(A and B) = P(A) x P(B). To calculate the expected frequency for a particular cell, one multiplies the row total percent by the column total percent, and these are in turn multiplied by the total number of observations (19,349). This is illustrated for the pay grade/AFSC combination EM03/202XX (the cell in the first row and second column of the table):

$$\text{expected frequency} = \frac{668}{19349} \times \frac{4757}{19349} \times 19349 = 164.2 \ .$$

The observed and expected frequencies are displayed as the first and second numbers, respectively, in each cell. One may notice that not all possible AFSC groups are represented, and that data for some pay grades (E1 and E2, E8 and E9) was combined. In order to properly apply a chi-square test, the number of cells with a small expected frequency (<5) should be kept to a minimum. In order to accomplish this, several small AFSC groups were not included, and the previously mentioned pay grades were combined. This procedure does not affect the conclusions which are drawn from this test.

The chi-square test is based on the fact that the observed freqencies should be reasonably good estimators of the expected frequencies if the hypothesis of independence is true. The chi-square statistic used in this test measures the relative difference between the observed and expected frequencies. The formula for this test statistic is shown below:

$$X = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(o_{ij} - e_{ij})^2}{e_{ij}}$$

where: X denotes the test or chi-square statistic,

o_{ij} denotes the observed frequency for the cell in the ith row and jth column,

e_{ij} denotes the expected frequency for the cell in the ith row and jth column,

r denotes the number of rows,

and c denotes the number of columns.

The contribution of each cell to the test statistic is displayed as the last number in each cell. For example, for cell EM03/202XX the contribution is calculated as follows:

$$\text{contribution} = \frac{(247 - 164.2)^2}{164.2} = 41.7 \ .$$

These numbers are summed to obtain the test statistic. If the observed value of the test statistic is too large the hypothesis of independence is rejected. How large is "too large" may be determined by consulting tables of the chi-square distribution, which are given in most statistics texts (e.g., [6] or [23]).

The value of the test statistic for this analysis is given in Figure 5. As can be seen, the observed value of X = 1830.328 results in a very small p value, $p < .0001$. The p value is the probability of getting this value of X or larger if pay grade and AFSC are, in fact, independent. Thus, in this case, there is overwhelming evidence that pay grade and AFSC are not independent. This implies that pay grade is not distributed in the same way among all operators of C-E equipment, and thus the assump-

tion underlying the use of the operator factor is invalid.

Further inspection of Figure 5 reveals evidence of where the difference in pay grade distributions occur. For example, AFSC 272XX (air traffic control) has an observed pay grade distribution that includes more personnel in the higher pay grades than is expected given the hypothesis of independence between pay grade and AFSC. Conversely, for AFSC 208XX (cryptologic linguist) there are more people assigned to the lower pay grades than expected.

2. Modification of the C-E Unit Level Report and the Operator Factor

As shown in the previous section, the assumption implicit in the use of the operator factor in its present form is invalid. The effects of the use of the operator factor coupled with the current lack of detailed operator data is illustrated in Figures 6 and 7. This hypothetical example is based on a combination of AFSCs which occurs in actual C-E organizations. Although the example is somewhat simplified, it does illustrate how the present allocation method can misstate the true operations cost. The magnitude of the misallocation depends on both the type of personnel at an organization and the relative amount of time one type of TMS is operated versus another type. Desmatics cannot determine the net effect of this problem using only presently available C-E organizational data (i.e., without knowing the specific personnel/TMS relationships).

In order to correct this shortcoming, Desmatics recommends that the present C-E Unit Level Report (RCS: HAF-LEY(A)8119) be modified to collect data to improve the operations personnel cost allocation. This report, a sample of which is shown in Figure 8, is required to be completed by each C-E organization annually, and returned to the Office of VAMOSC. It

AFSC	GRADE	#	PAY	COST
272X0	E01	0	$ 9,472	$ -0-
	02	4	10,632	42,528
	03	17	11,727	199,359
	04	25	14,402	360,050
	05	28	17,050	477,400
	06	12	20,331	243,972
	07	10	23,937	239,370
	08	3	27,750	83,250
	09	1	32,793	32,793
		100		$1,678,722

AFSC	GRADE	#	PAY	COST
291X0	E01	1	$ 9,472	$ 9,472
	02	6	10,632	63,792
	03	26	11,727	304,902
	04	32	14,402	460,864
	05	21	17,050	358,050
	06	9	20,331	182,979
	07	4	23,937	95,748
	08	1	27,750	27,750
	09	0	32,793	-0-
		100		$1,503,557

- Assume hypothetical C-E organization with two groups of personnel:

  AFSC 272X0-Air traffic control operations,
  AFSC 291X0-Telecommunications operations.

- Assume 4 TMSs: A and B are air traffic control equipments,
  C and D are telephone equipments.

- Assume it is known that the 272X0s operate items A and B only; 291X0s operate C and D only.

- All data are for illustrative purposes only; however, the distribution across pay grade is consistent with that observed in MPC data using FY82 selection logic.

Figure 6: Hypothetical Data Used in Operations Personnel Cost Allocation Comparison

AFSC	TMS	Op	Allocated By Current Method		Allocated By Proposed Method		Actual Costs (from Figure 5)	
272X0	A	.45	$1,432,025		$1,259,042		$1,259,042	
272X0	B	.15	477,342		419,680		419,680	
				$1,909,367		$1,678,722		$1,678,722
291X0	C	.30	$ 954,684		$1,127,668		$1,127,668	
291X0	D	.10	318,228		375,889		375,889	
		1.00		$1,272,912		$1,503,557		$1,503,557
				$3,182,279		$3,182,279		$3,182,279

- Current algorithm allocates by: Total operations cost x Op_i, for all i
  - thus: 3,182,279 x .45 = 1,432,025 TMS A
    3,182,279 x .15 = 477,342 TMS B
    3,182,279 x .30 = 954,684 TMS C
    3,182,279 x .10 = 318,228 TMS D

- Proposed algorithm allocates by: AFSC group operations cost x $\frac{Op_j}{\Sigma Op_j}$
  - where: ΣOp_j denotes the sum of the Ops for all TMSs operated by the particular AFSC group

thus: $1{,}678{,}722 \times \frac{.45}{.45+.15} = 1{,}259{,}042$ TMS A

$1{,}678{,}722 \times \frac{.15}{.45+.15} = 419{,}680$ TMS B

$1{,}503{,}557 \times \frac{.30}{.30+.10} = 1{,}127{,}668$ TMS C

$1{,}503{,}557 \times \frac{.10}{.30+.10} = 375{,}889$ TMS D

Figure 7: Comparison of Current and Proposed Operations Personnel Cost Allocation Algorithms

VAMOSC II C-E UNIT LEVEL REPORT (DATE: 12/23/82)
COMMUNICATION EQUIPMENT DATA
(RCS: HAF-LEY(A)8119)

UNIT: 3700RMS70000

		REPORTING	SUPPORTING
1.	OAC/OBAN	6410	6431
2.	RC/CCS	---------	----------

3. ENTER THE TOTAL NUMBER OF OPERATION MANHOURS PER DAY
(INCLUDE ALL PERSONNEL IN FAC 38XX, EXCEPT 3800, 3801, 3802)

4. EQUIPMENT DATA

TMS	OPERATOR ATTENTION REQUIRED? (YES OR NO)	HRS ATTENDED PER DAY	NO OF OPERATORS REQUIRED
U1H002	----------	----------	----------
110002	----------	----------	----------

REMARKS:

Figure 8: Sample C-E Unit Level Report

is necessary to develop operator-to-TMS relationships in order to correctly allocate an operator's pay to only the TMS (or TMSs) he operates. In order to ascertain these relationships, the C-E organizations should provide the AFSC or AFSCs of the personnel who regularly operate each equipment on a revised C-E Unit Level Report. With this information, operator factors can be developed for each AFSC group, as is shown in Figure 7. This will permit only the costs of the actual operators of an end item to be allocated to that end item.

Several other problems with this algorithm can also be remedied by other changes to the Unit Level Report. The following examples serve to demonstrate these points. According to the instructions for completing the Unit Level Report as given in AFR 400-31, Volume I [16], the organization will provide the average number of hours each TMS is attended by an operator each day (from 1 to 24) and the maximum number of operators attending the equipment at any given time. The Office of VAMOSC then multiplies these figures, presumably giving the total daily operator hours per TMS. These daily hours are summed for all TMSs at that organization requiring operators. The operator hours figure for each TMS is divided by this organization total, giving the operator factor for that TMS. However, in many cases this will result in an inaccurate operator factor. For example, suppose a TMS is attended for 16 hours per day: two operators are required for the first 8 hours and one operator is required for the second 8 hours. By following the instructions mentioned above, the total daily operator hours would be 2 X 16 = 32. However, a total of 24 man-hours was actually expended.

To illustrate another characteristic of this algorithm, consider

this situation: Operator A attends TMS X for 4 hours a day. This is the only equipment he operates. Operator B similarly attends only TMS Z for 2 hours a day. Obviously each operator is on duty more than 2 or 4 hours a day. They remain "operators" even when not attending the equipment, and consequently all of their salaries should be allocated to their respective TMSs. Presently, their pay will be allocated to the equipment in the ratio of the attended time on a TMS to the total attended time. This would show TMS X as costing twice as much to operate as TMS Z, when actually the difference in operating cost should only represent the difference in the salaries of the operations personnel involved.

In order to avoid these two problems with the operator factor, Desmatics recommends that the Unit Level Report be changed by eliminating the columns for attended hours and number of operators, and replacing them with a column for the reporting of the total number of man-hours someone is "assigned" to the end item per day. The term "assigned" as used here refers to having someone on duty who is responsible for operating a specific end item (or items). In the case of operators A and B mentioned above, Operator A would be assigned to equipment X for his entire shift, not just the 4 hours he attends the item. Similarly, Operator B would be considered assigned to equipment Z for his entire shift. Then, the difference in the operations cost will be the difference in the salaries.

A similar procedure will also work when a person operates more than one TMS. That person's hours must be prorated over the equipments operated on the basis of the time spent on each one. For instance, a person is on duty for eight hours and operates two items, R and S, for 1 hour and 3 hours respectively on the average. The time would be split

thusly:

1/(1+3) X 8 = 2 hours for item R

3/(1+3) X 8 = 6 hours for item S.

When this assigned manpower column is completed correctly, it should total to the number of operator man-hours expended per day by the organization. This will provide a check for the person filling out the form and should be stated as such in the instructions. It should also be made clear that the man-hours reported on a TMS should be for the total for all occurrences of that TMS at that organization, in the case of a unit which operates more than one of an end item.

It is very important to provide thorough and unambiguous instructions for completion of the C-E Unit Level Report in order to gain the maximum amount of useful information. As mentioned previously, the instructions can mention checks the person filling out the report can do to ensure that the data is reasonable. It would also be advantageous to provide examples which would serve to guide the personnel through any calculations which need to be done, such as partitioning man-hours between equipments. Regardless of any modifications to the C-E Unit Level Report, the Office of VAMOSC should continue its practice of developing operator factors which are based on all C-E end items requiring operators.

V. BASE MAINTENANCE PERSONNEL COST

Base maintenance personnel cost is the pay and allowances of personnel required for below depot maintenance of C-E end items. The D160A system computes base maintenance personnel costs by AFSC rather than by FAC because maintenance personnel of a particular AFSC group (e.g., 304X0) are responsible for specific TMSs. This AFSC-to-TMS relationship was developed by the Office of VAMOSC by surveying commands with C-E equipments and by reviewing AFCCR 26-3, "Manpower Standards."

A. PROCESS DESCRIPTION

The algorithm described in this section was used to develop base maintenance personnel costs for both FY81 and FY82 C-E processing. Base maintenance personnel records are selected from the E300Z records passed to D160A (C-E) by VAMOH, as described in Section III. Although the records are selected by FAC, the costs are developed to the AFSC of the personnel.

The base maintenance personnel costs are computed by multiplying the number of personnel in a FAC/AFSC/Grade combination within an organization by the average pay rate for that grade, as obtained from AFR 173-13 [14]. The costs for each AFSC are computed for all C-E organizations and totaled, giving the Air Force-wide cost for each maintenance AFSC. The total cost for an AFSC is then accumulated to an AFSC group.

The costs for each group must then be allocated to the TMSs as-

sociated with that group. A base labor allocation factor (L_B) is calculated for each TMS:

$$L_B = \frac{H}{N \times H_{ST}}$$

where H = maintenance man-hours as reported in D056A plus support general hours (preventative maintenance inspection standard hours) for that TMS worldwide [9],

N = the number of personnel in the maintenance AFSC group associated with that TMS,

and H_{ST} = annual available duty hours for a C-E maintenance person, as developed by the Office of VAMOSC. In FY81 and FY82 processing, a value of 1738 hours was used [4].

This ratio indicates the portion of the total duty hours of maintenance personnel within that AFSC group attributable to a TMS. The total labor cost for an AFSC group, as computed above, is multiplied by the L_B for a particular TMS, thereby allocating a portion of these costs to that TMS. A TMS data file used by the C-E system contains the AFSC group of the maintenance personnel who repair each item [7,18].

B. EVALUATION

In Desmatics' opinion, the relationship of maintenance AFSC group to TMS provides a sound basis for allocating base maintenance personnel costs to C-E end items. However, the L_B factor is a potential source of cost allocation inaccuracy because of its reliance on the estimated parameter, H_{ST}. It should be noted that the inaccuracy would be in the absolute dollar amount allocated to a TMS (either an understatement or overstatement, depending on the value of H_{ST}). However, the cost of one TMS

relative to another is not affected by this factor. The following sections address topics associated with the L_B factor and contracted costs.

1. An Ideal Formulation for the L_B Factor

The ideal formulation for the allocation of base maintenance personnel costs would be:

$$L_B = \frac{H_i}{\Sigma H_i}$$

where H_i = maintenance man-hours as reported in D056A plus support general hours for the ith C-E TMS worldwide,

and ΣH_i = the sum of all maintenance man-hours and support general hours for all TMSs associated with the AFSC group supporting the TMS to which the particular L_B applies.

This would allow for an accurate allocation of the costs because it avoids the use of H_{ST}. However, because a number of TMSs or organizations are exempt from maintenance man-hour reporting, the ideal formulation of L_B cannot be used. Since maintenance personnel can work on both exempt and nonexempt items, to use the ideal formulation with the presence of exemptions would allocate all of the pay and allowances to only the nonexempt items, and consequently overstate their maintenance costs.

Items or organizations may be exempt from reporting requirements for one of several reasons. For example, end items which are within six months of being phased out of the inventory are eligible for exemption. Also,

in some cases maintenance done by contractors may be exempt from reporting maintenance man-hours as an economy measure. All exemptions for these or any other reasons must be approved by HQ USAF/LEYM [22]. Since these exemptions are detrimental to the C-E system, Desmatics suggests that the Office of VAMOSC strongly encourage the elimination of reporting exemptions.

Since reporting exemptions do presently exist, however, the Office of VAMOSC should indicate on the O&S cost reports for the affected TMSs that the reported maintenance cost figure only represents a portion of the actual maintenance costs because of reporting exemptions. An alternative would be to decrease the inventory figure that is shown on the C-E reports by eliminating the inventory of those end items at organizations not required to report on them. Of course, should Air Force policy discontinue exemptions, the ideal formulation of L_B should be used to allocate costs.

2. Modification of the Present L_B Formulation

As stated in the previous section, the C-E system is currently constrained to using the parameter H_{ST} in the L_B factor. This parameter represents the number of productive man-hours that are available per person per year, exclusive of elements such as leave, training, and TDY. However, in Desmatics' opinion, the below depot maintenance costs for C-E end items are understated, because the present formulation of L_B does not account for the true nature of the maintenance workload (i.e., people are not effectively employed for 100% of their productive man-hours).

This phenomenon may be accounted for in the formulation of L_B by the use of an efficiency factor. Efficiency factors are commonly used in maintenance manpower estimation in life cycle cost models.

The efficiency factor may take on a value between 0 and 1. For example, May [5] uses a value of .6 (.75 in an earlier edition). Desmatics recommends that an efficiency factor be incorporated into the present L_B factor formulation. The Office of VAMOSC should investigate this area to determine an appropriate value, should it choose to incorporate this factor into the L_B. The modified L_B would then be of this form:

$$L_B = \frac{H}{N \times H_{ST} \times E}$$

where: H = maintenance man-hours as reported in D056A plus support general hours for a C-E item worldwide,

N = the number of personnel in the maintenance AFSCs associated with the TMS,

H_{ST} = annual available duty hours,

and E = efficiency factor.

One method of obtaining an estimate of the efficiency factor begins with identifying any organizations which have only equipments which are reported in D056. The following equation can then be solved for an estimate of E:

$$\hat{E} = \frac{H_x}{N_x \times H_{ST}}$$

where: $\hat{E}$ = estimate of efficiency factor,

H_x = total maintenance man-hours as reported in D056 for the desired organization(s),

and N_x = total number of personnel with maintenance AFSCs in the desired organization(s).

Theoretically, if the efficiency factor E were chosen correctly, the sum of the L_B factors for any given AFSC group should be less than or equal to 1.0. Of course, it is conceivable that the sum of the L_B factors may be greater than 1.0, e.g., because of an underestimate of the value of E. This would result in more than 100% of the total maintenance costs (for the AFSC group in question) being allocated to the TMSs.

To avoid such situations, Desmatics suggests that the D160A system check each AFSC group to see whether the corresponding L_B sum is greater than 1.0. If so, the system logic should redefine each individual L_B in the sum by multiplying it by the proportion necessary to reduce the sum to a value of 1.0. Thus, for example, if the L_B sum for a given AFSC group was found to be 1.25, each individual L_B would be multiplied by .80 before being used for cost allocation.

It should be pointed out once again that in the absence of reporting exemptions the ideal formulation of L_B should be used. It does not require an efficiency factor as it is a ratio of reported man-hours, and does not rely on the use of H_{ST}. Also, the ideal formulation will never result in a value greater than one.

3. Contracted Below Depot Maintenance and Operations Costs

At present, the C-E system is not capturing the contracted below

depot maintenace and operations cost for C-E end items. For example, in the FY82 cost records passed to C-E by VAMOH are records for approximately $100 million in contract costs associated with the Ballistic Missile Early Warning System (BMEWS) and surveillance radar sites (PECs 12431 and 12411, and EEIC 592XX).

Current C-E logic does not allocate these contract costs to any end items, although end items at these installations are included in the C-E system. The Office of VAMOSC should investigate the nature of these contracts to identify the particular equipments involved in order to determine the feasibility of developing an algorithm to allocate these costs to the TMS level.

VI. ADMINISTRATIVE PERSONNEL COST

Administrative Personnel Cost is defined in AFR 400-31, Volume III [18], as the "...total cost of paying administrative personnel required at the organizational level for support of a C-E end item (TMS) at all C-E organizations at all bases." Administrative personnel perform indirect support functions in such areas as program management, flight facilities operations, air traffic control, air traffic control training, C-E maintenance, and C-E quality control.

A. PROCESS DESCRIPTION

The number of personnel in each administrative PAS/FAC/Grade combination is obtained from the MPC records as described in Section III. The average pay rate for each grade is obtained from pay tables [10]. The cost for each PAS/FAC/grade combination at each organization is obtained by multiplying the number of personnel having that combination by the corresponding average pay rate for that grade. These costs are first summed to each FAC, then over all administrative FACs at the organization to obtain the total administrative personnel costs for the organization. These costs are allocated to end items at each organization using the TMS allocation factor (f_{TMS}). This factor is the ratio of the total value of the inventory of a particular TMS at an organization to the total value of the inventory of all TMSs at the organization. The inventory counts of end items and unit prices (Air Force stock list prices) are obtained from the D039 system interface. The general equation for the factor is:

$$f_{TMS_i} = \frac{Q_i \times P_i}{\sum_i Q_i \times P_i}$$

where Q_i = the inventory of TMS_i at an organization,

and P_i = Air Force stock list price of TMS_i.

To obtain the total allocated administrative personnel costs for each TMS the costs allocated at the organizational level are summed over all C-E organizations worldwide.

B. EVALUATION

Using actual assigned personnel strengths and average pay rates should provide a reasonably accurate estimate of total administrative personnel costs at a C-E organization. Desmatics, however, does not agree with the use of the unit TMS factor for allocation purposes. This factor allocates these costs on the basis of the relative replacement costs for end items in an organizational inventory. A more appropriate cost driver would be related to the ongoing operating and maintenance requirements of an end item. The duties and responsibilities associated with those FAC/AFSC combinations assigned to administrative personnel relate to supervisory, management, or other support activities, which are of an overhead nature [12,13,15]. An allocation procedure for these costs based on strengths (numbers of personnel) associated with an organization is intuitively reasonable since one would expect that these administrative activities would vary more or less directly with these personnel strengths. Desmatics therefore suggests a procedure based on numbers of operations and maintenance personnel strengths. Since the Office of VAMOSC favors,

and Desmatics concurs with, including supply support personnel (discussed in Section VII) in administration, costs for these personnel are included as part of administrative personnel costs in this allocation method. For any TMS_i, its worldwide share of administrative personnel costs, A_i, is developed as follows:

1. Determine the total administrative personnel costs, A_y, at each C-E organization (this includes supply support personnel costs) as described previously and in AFR 400-31, Volume III.

2. For each C-E organization, allocate the administrative personnel costs, A_y, to operations and maintenance based on the relative personnel strengths assigned to each of these functions at the organization. The allocation equations are:

$$Ao_y = A_y \times \frac{O_y}{O_y + M_y}$$

and

$$Am_y = A_y \times \frac{M_y}{O_y + M_y}$$

where Ao_y = operations share of administrative personnel costs at organization y,

Am_y = maintenance share of the administrative personnel costs at organization y,

A_y = total administrative personnel costs at organization y,

O_y = number of operations personnel at organization y,

and M_y = number of maintenance personnel at organization y.

3. Allocate the operations share, Ao_y, of administrative personnel costs to TMS_i at each organization as follows:

$$Ao_{iy} = w_{iy} \times Ao_y$$

where Ao_{iy} = share of operations portion of administrative personnel costs at organization y allocated to TMS_i,

and w_{iy} = operations workload of TMS_i at organization y (discussed in Section IV, this report).

4. Sum the shares of the operations portions of administrative personnel costs allocated to TMS_i over all organizations to get the worldwide operations portion of administrative personnel costs, Ao_i, for the TMS.

$$Ao_i = \sum_y Ao_{i_y}$$

5. Sum the maintenance portions, Am_y, of administrative personnel costs over all organizations to get the worldwide maintenance portion, Am, of C-E administrative personnel costs.

$$Am = \sum_y Am_y$$

6. Allocate the worldwide maintenance portion of administrative personnel costs to $AFSC_j$ using a ratio of these strengths to the total maintenance strengths worldwide, then to TMS_i using the Base Labor Allocation Factor for this TMS and AFSC. This gives the maintenance portion of administrative personnel costs, Am_i, for TMS_i worldwide.

$$Am_i = Am \times \frac{n_j}{M} \times L_{B_i}$$

Here: Am_i = share of maintenance portion of administrative personnel costs allocated to TMS_i, worldwide,

Am = maintenance share of administrative personnel costs worldwide,

n_j = number of maintenance personnel with $AFSC_j$ ($AFSC_j$ supports TMS_i) worldwide,

M = total number of C-E maintenance personnel worldwide,

and L_{B_i} = Base Labor Allocation Factor for TMS_i and $AFSC_j$ (discussed in Section V, this report).

7. Sum the allocated operations and maintenance shares of administrative personnel costs for TMS_i to get the total worldwide share of administrative personnel costs, defined as A_i, for the TMS.

$$A_i = Ao_i + Am_i$$

VII. SUPPLY SUPPORT PERSONNEL COST

Supply support personnel cost is defined in AFR 400-31, Volume III [18], as "... the total cost of paying supply support personnel required at the organizational level for support of a C-E end item (TMS) at all C-E organizations at all bases." Supply support personnel, functioning primarily as a liaison between the C-E unit and base supply, are involved mainly in reporting on routine activities associated with maintenance of C-E equipment. Because of their relatively small numbers (less than 2% of all C-E personnel) and the administrative nature of their duties, the Office of VAMOSC is considering reclassifying these personnel as administrative personnel and adding their costs to the corresponding cost category.

A. PROCESS DESCRIPTION

Supply support personnel counts are obtained for each C-E organization as described in Section III. Average pay rates by grade are obtained from pay tables [10]. The total cost of supply support personnel at each organization is computed by multiplying the number of personnel in each PAS/FAC/grade by the average pay rate for the grade and summing over all the resulting products. This cost total is then allocated to each TMS in the organizational inventory using the unit TMS allocation factor (f_{TMS}) discussed in the previous section. The Air Force-wide cost of supply support personnel for a TMS is the sum of these allocated costs over all organizations possessing that TMS.

B. EVALUATION

Because of the administrative nature of the supply support function in C-E, Desmatics agrees with the Office of VAMOSC regarding the grouping of associated personnel costs in the Administrative Personnel Cost category. Desmatics is of the opinion, however, that the unit TMS factors (f_{TMS}) is not appropriate for the allocation of supply support personnel costs to end items, whether categorized as such or not. It seems appropriate not only to group these personnel in administration, but also to allocate their costs among end items as was suggested for other administrative personnel costs in the previous section.

VIII. CONCLUSIONS, RECOMMENDATIONS, AND OFFICE OF VAMOSC COMMENTS

This volume has presented an evaluation of the C-E cost allocation algorithms for the four areas presently defined by the system as Unit Mission Personnel costs: Operations, Base Maintenance, Administrative, and Supply Support. In addition, the processes C-E used in FY81 and FY82 to select and categorize the personnel records into the four categories were examined.

A. SUMMARY

In Desmatics' opinion, the process which C-E used to select and classify personnel records for costing purposes in FY82 could be improved since it miscategorized some records and did not select many records which Desmatics considers relevant. Desmatics proposes an alternative strategy which would expand the scope of this procedure. Suggestions for recategorization are also put forth.

The effectiveness of the four unit mission personnel algorithms is weakened by their corresponding allocation factors. The implicit assumption underlying the use of the operator factor to allocate operations personnel costs has been shown to be invalid by Desmatics. The base labor allocation factor, used to allocate below depot maintenance personnel costs, must rely on the use of an estimated parameter as a result of maintenance man-hour reporting exemptions, and is therefore subject to inaccuracy. The unit TMS allocation factor, used to allocate both administrative and supply support personnel costs, has little intuitive

appeal since a TMS's value has low face validity as a driver of these two types of cost. Desmatics has outlined suggested modifications of each of these allocation algorithms and the associated factors to improve the C-E system.

B. RECOMMENDATIONS AND REPLIES

This section lists Desmatics' conclusions and recommendations regarding the C-E Unit Mission Personnel algorithms. The responses or comments of the Office of VAMOSC are included.

1. C-E Organization Concept (See Pages 16-19)

Conclusions: While most C-E end items are owned and operated by C-E mission organizations (mostly but not exclusively within AFCC), some items are operated by other organizations whose missions are not principally C-E oriented. Desmatics contends that VAMOSC should include end item costs for both situations. However, end items in non-C-E mission organizations would require special treatment of personnel costs.

Recommendation: The Office of VAMOSC should consider providing separate visibility for the equipments owned by non-C-E organizations.

Office of VAMOSC Comments: "Concur. The Office of VAMOSC is designing a methodology to accurately assign C-E costs associated with equipment not owned by C-E organizations. The expected implementation date is FY84."

2. C-E Personnel Cost in C-E Mission Organizations (See Pages 14-16)

Conclusion: For equipments owned by C-E organizations, the current VAMOSC logic excludes all unit personnel who are not in FACs 26XX, 35XX, or 38XX. Even within these FACs there are personnel who are currently excluded.

Recommendation: Desmatics contends that all relevant personnel within a C-E mission organization should be costed against the end items in its inventory. The Office of VAMOSC should revise the unit personnel selection logic to insure that all such personnel are included.

Office of VAMOSC Comments: "Concur. Power production, refrigeration and heating, and vehicle maintenance personnel will be added and algorithms devised to allocate the cost of these personnel to end items. The Office of VAMOSC will continue to review input files for other personnel that should be included."

3. C-E Personnel Cost in Other Organizations (See Pages 17-19)

Conclusion: Certain C-E unit mission personnel in non-C-E mission organizations can be identified by presently specified AFSCs, and can be costed to the C-E end items in the units' inventories. Other personnel within such organizations are not primarily C-E oriented and should not be costed against C-E end items.

Recommendations: The Office of VAMOSC should identify C-E unit mission personnel within non-C-E mission organizations and cost these personnel to the C-E end items of these organizations.

Office of VAMOSC Comments: "Concur. For FY84 reports, FAC 34XX will be added to obtain meteorological equipment operator cost. Personnel data will be reviewed for other C-E equipment operators (AFSCs with C-E operations as primary function). The Office of VAMOSC does not intend to cost C-E equipment operators where these operations are an ancillary task. Action on the recommendation to cost certain organizations (non-C-E) separately will be held in abeyance pending review of all algorithms."

4. Portrayal of Personnel Strengths (See Pages 18-19)

Conclusion: By displaying the number of personnel associated with an end item on its operating and support (O&S) Cost Reports, C-E could provide additional useful information to its users.

Recommendation: The Office of VAMOSC should present personnel strengths on its C-E O&S Cost Reports, allocating the personnel counts by the same means as the corresponding costs.

Office of VAMOSC Comments: "Concur in principle. The Office of VAMOSC will review the cost of implementation during FY84. The possibility of an incorrect application will also be considered. Based upon the results of these inquiries, a decision regarding implementation will be made during FY85 for FY86 implementation."

5. Collection of Additional Operations Personnel Data (See Pages 22-31)

Conclusion: Desmatics has shown that the distribution of operations personnel within pay grades differs across career fields. This invalidates the use of the operator factor in its present form. Therefore, the present algorithm is not allocating these costs in an optimal manner.

Recommendation: The Office of VAMOSC should modify the C-E Unit Level Report so that the organizations provide the AFSC or AFSCs of the operators of each TMS thus allowing allocation of the pay and allowances of only the relevant operators to each TMS.

Office of VAMOSC Comments: "Concur. A field will be established in the TMS-NSN table for an operator AFSC. The operator cost algorithm will be revised accordingly for FY84 reports."

6. Redefinition of the Operator Factor (See Pages 31-33)

Conclusion: The operator factor's present definition as an attended-hour ratio presents a misleading representation of operations personnel costs in certain situations.

Recommendation: The Office of VAMOSC should further modify the information requested on the C-E Unit Level Report. The TMS attended hours presently collected should be replaced by requesting the portion of the operators' man-hours per day assigned to each TMS requiring an operator. The operator factor for a TMS would then be the ratio of the assigned man-hours on that TMS to the organization's total assigned man-hours.

Office of VAMOSC Comments: "Concur. Report will be changed accordingly for FY84 reports."

7. Base Maintenance Personnel Cost and Reporting Exemptions (See Pages 35-37)

Conclusion: The exemption of certain organizations and certain TMSs from maintenance reporting misstates the maintenance costs on all TMSs.

Recommendation: The Office of VAMOSC should strongly encourage the elimination of reporting exemptions, as they are detrimental to the C-E system. Should Air Force policy eventually eliminate exemptions, the ideal formulation of L_B suggested by Desmatics should be used in cost allocation. Until then, however, the Office of VAMOSC should indicate if an item is subject to reporting exemptions on that item's O&S cost report. An alternative would be to alter the reported average inventory figure to show only the number of TMSs at organizations required to report on those items.

Office of VAMOSC Comments: "Concur. FY82 reports will show exemptions, and previsions will be available to change inventory quantities."

8. Use of An Efficiency Factor in L_B (See Pages 37-39)

Conclusion: The present L_B factor used to allocate below depot maintenance costs to the TMS level does not reflect true nature of the maintenance workload. In general, the factor as currently defined results in an understatement of maintenance costs.

Recommendation: The Office of VAMOSC should add an efficiency factor to the present formulation of L_B in the manner suggested by Desmatics. This new formulation should be used as long as reporting exemptions affect C-E end items. The value of the factor should be determined through consultation with cognizant Air Force personnel.

Office of VAMOSC Comments: "Concur in principle. Further investigation is necessary to improve the allocation process. Data is not currently available to evaluate what is the desired level of reporting. Alternatives to determining the exact level of effort of C-E technicians will be pursued."

9. Contracted Operations and Below Depot Maintenance Costs (See Pages 39-40)

Conclusion: The C-E system is currently not capturing contracted operations and below depot maintenance costs.

Recommendations: The Office of VAMOSC should investigate the nature and extent of these Air Force contracts to develop a means of capturing and allocating any appropriate contract costs.

Office of VAMOSC Comments: "Concur in part. Complete systems operated under a contract, such as BMEWS, will no longer be costed by VAMOSC as the contract covers all areas and no benefit would occur by having a VAMOSC report for these systems. We will try to obtain contract costs for those TMSs that are operated and maintained by both AF and civilian contracts. HQ AFLC has formed a working group with the charter to collect non-industrially funded depot maintenance costs. Below depot costs are not currently collected and reported by SRD or NSN. These costs cover areas beyond unit mission personnel, and opportunities to collect and report these costs will continue to be pursued."

10. Allocation of Administrative and Supply Support Personnel Costs (See Pages 42-44, 46)

Conclusion: The unit TMS allocation factor (f_{TMS}) is inappropriate for the assignment of administrative and supply support personnel costs. There is little justification for basing allocation of these expenses on the cost of equipments assigned to organizations.

Recommendation: The Office of VAMOSC should consider allocating administrative and supply support personnel costs to end items using a ratio based on operations and maintenance personnel strengths.

Office of VAMOSC Comments: "Concur. New algorithms will be developed during FY84 for FY85 processing."

11. Classification of Supply Support Personnel (See Pages 45-46)

Conclusion: Desmatics agrees with the Office of VAMOSC that it is appropriate to include supply support personnel costs in the administrative category.

Recommendation: The Office of VAMOSC should implement this change in the estimation and portrayal of C-E Unit Mission Personnel Costs.

Office of VAMOSC Comments: "Concur. VAMOSC will add this category to unit administration as planned for FY85 processing."

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